Spacesuit and Space Vehicle Comparative Ergonomic Evaluation

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ABSTRACT

With the advent of the latest manned spaceflight objectives, a series of prototype launch and reentry spacesuit architectures were evaluated for eventual down selection by NASA based on the performance of a set of designated tasks. A consolidated approach was taken to testing, concurrently collecting suit mobility data, seat-suit-vehicle interface clearances and movement strategies within the volume of a Multi-Purpose Crew Vehicle mockup. To achieve the objectives of the test, a requirement was set forth to maintain high mockup fidelity while using advanced motion capture technologies. These seemingly mutually exclusive goals were accommodated with the construction of an optically transparent and fully adjustable frame mockup. The mockup was constructed such that it could be dimensionally validated rapidly with the motion capture system. This paper will describe the method used to create a motion capture compatible space vehicle mockup, the consolidated approach for evaluating spacesuits in action, as well as the various methods for generating hardware requirements for an entire population from the resulting complex data set using a limited number of test subjects.

Kinematics, hardware clearance, suited anthropometry, and subjective feedback data were recorded on fifteen unsuited and five suited subjects. Unsuited subjects were selected chiefly by anthropometry, in an attempt to find subjects who fell within predefined criteria for medium male, large male and small female subjects. The suited subjects were selected as a subset of the unsuited subjects and tested in both unpressurized and pressurized conditions. Since the prototype spacesuits were fabricated in a single size to accommodate an approximately average sized male, the findings from the suit testing were systematically extrapolated to the extremes of the

population to anticipate likely problem areas. This extrapolation was achieved by first performing population analysis through a comparison of suited subjects' performance to their unsuited performance and then applying the results to the entire range of population.

The use of a transparent space vehicle mockup enabled the collection of large amounts of data during human-in-the-loop testing. Mobility data revealed that most of the tested spacesuits had sufficient ranges of motion for tasks to be performed successfully. A failed tasked by a suited subject most often stemmed from a combination of poor field of view while seated and poor dexterity of the gloves when pressurized or from suit/vehicle interface issues. Seat ingress/egress testing showed that problems with anthropometric accommodation does not exclusively occur with the largest or smallest subjects, but rather specific combinations of measurements that lead to narrower seat ingress/egress clearance.